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(54) TOBACCO LEAF CURING SYSTEM

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TITLE

TOBACCO LEAF CURING SYSTEM

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ABSTRACT

An automatically controlled tobacco leaf curing system employs a kiln, and means for measuring the dry and wet bulb temperatures in the kiln. Sensors on the dry and wet bulb temperatures control, from the respective measurements, the velocity of circulation, and the temperature of the internal air of the kiln (including its humidity) and the amount of ambient air permitted to be introduced into the kiln to replace the regulated vented hot humid air. In this environment it is necessary to periodically ignite and to extinguish a burner which provides the heat for the hot circulating air in order to maintain the necessary temperatures, as well as to regulate the amount of air vented from the kiln and fresh air brought from the ambient air into the kiln.

Tobacco leaves cannot be dehydrated and cured or dried by usual physical or mechanical curing or drying means, because of special physical structure and characteristics peculiar to their cells. Accordingly, unless the yellow coloring and the curing process is carried out with a proper adjustment of the dehydration speed and drying or curing temperature which does not destroy the cell of leaves, deterioration of the quality of the cured leaves will result.

Accordingly, what is important in drying or curing tobacco leaves is to prevent the cell from getting excessively dried by controlling the humidity of the ambient temperature of the leaves in curing process and the latent heat given to the cell so as not to destroy the cell.

The tobacco leaves curing process is usually divided, for convenience, into the first half period comprising the preheating stage for fermentation and the yellow coloring stage and the second half period comprising the leaf drying stage and the stem drying stage.

In the first period, saccharification of ingredients and therefore chemical and physiological change in leaves proceeds for about 30 to 40 hours by the action of the active enzyme in the leaves while maintaining the temperature and water content of the leaves at a proper level.

During the first process period, green color of the leave due to the chlorophyll content vanishes and yellow color resulting from carochine content appears, and the leave comes to take a yellow color, which is peculiar to ordinary tobacco leaves.

The fermantation pre-heating and yellow coloring stage of the first half period can be carried out selectively and mechanically easily by conventional circulation drying methods bulk curing which circulate wet hot air through leaf chamber to cause chemical change of the leaf ingredients

In the second half period consisting of mesophyll setting and stem drying processes, the mesophyll and stem are dried and they are finished to dried tobacco leaves having a good quality, a good aroma and smoking property. In the second period, however, extremely elaborate and complicated adjustment is required but often failure occurs in drying and accordingly, deterioration of quality of leaves cured which leads to loss.

The reason for this difficulty or failure is this: while the latter half period consists only of such mechanical and physical process as extraction of water from the mesophyll, the process should be turned from the first half stage to the latter stage very carefully. That is, the process in the first period should be performed maintaining such a proper upper limit temperature as not to destruct the leaf cell and as to cause the leaves color to change yellow; then the process should be turned slowly to a leaf drying or dehydration stage in the second half period, with a very minute care, without causing a drop in the leaf temperature due to the evaporation of moisture from leaves.

Most of the failure in the past has been caused by the difficulty in the smooth change from the first period to the latter period because the changing operation includ-

es a complicated temperature and humidity control requirement.

According to such conventional method of changing slowly from the curing process to the drying process, a "Standard Drying Operation Table" as shown in Figure 24 has been used. In the conventioned method, temperature adjustment has been conducted by always checking the balance between the dry-bulb temperature and the wet-bulb temperature of the curing barn while referring to the operation table.

With respect to the relationship between the dry-bulb and the wet-bulb temperatures during the drying process, followings should be noted. Namely, the dry-bulb temperature rises successively insteps while the wet-bulb temperature maintains linearity from the beginning to the end, at up to about 38°C and almost stays there. In failed examples, it was found that the wet-bulb temperature fluctuated in wave like fashion.

In tobacco leaf curing process of prior art, the following problems or facts were encountered.

1. The wet-bulb temperature is maintained substantially at 38°C without any remarkable variation throughout the process while the dry-bulb temperature gradually rises step by step.

2. Fluctuation of the wet-bulb temperature in waves is observed in the case of failure.

3. The moisture evaporating rate from the cloth piece such as wet-bulb gauze is closely similar to that from the surface of tobacco leaf within the curing barn.

4. The temperature of the cloth piece such as the

wet-bulb gauze is also closely similar to that on the surface of tobacco leaf so that the drying extent of the cloth piece, namely, the indication of the wet-bulb temperature suggests that on the surface of tobacco leaf. For example, regulation of the wet-bulb temperature at 38°C is to control the moisture evaporating rate of tobacco leaf at 38°C.

I have noted that the water evaporation speed on the surface of the cloth piece convering the wet-bulb in the drying chamber in quite similar to that on the surface of the tobacco leaves. When both evaporation speeds are quite alike, the temperature of both surfaces are quite similar, accordingly the temperature of the leaves can be known by observing the drying degree of the convering cloth piece of the wet-bulb, i.e., the wet-bulb temperature. In short, to adjust the wet-bulb temperature at around 38°C is to set the water evaporation speed for the leaf at an evaporation speed level of around 38°C.

Accordingly, in view of the fact that it is necessary to stabilize the wet-bulb temperature around 38°C degree in order to succeed in drying leaves, one of the purposes of this invention is to provide a tobacco leaf drying system which dries tobacco leaves perfectly and completely at the natural temperature rise starting from about 43°C of the dry-bulb temperature while stabilizing the wet-bulb temperature at about 38°C, also in the second half period (At the beginning of the mesophyll drying stage where moisture in the leaf evaporates actively, most of the heat supplied by the burner are used as the latent heat for the evaporation of the water of the leaf and accordingly does not serve to raise the dry-bulb temperature. But in

the later part of the mesophyll setting process where the leaf becomes almost dried, the evaporation of the moisture drops, and the amount used as the latent heat becomes less. Accordingly more the burner heat is to be used spontaneously to raise the temperature of the dry-bulb. This I call a "spontaneous temperature rise of the dry-bulb".)

In the mesophyll drying and stem drying stage it is necessary to control intake and exhaust of the circulating air in the crying chamber (the Bulk curing barn) while keeping the wet-bulb temperature set about 38°C. This air control makes an important contribution in tobacco leaf drying process, along with the control of the wet-bulb temperature.

Drying of the leaf i.e., evaporation of the water in the leaf is possible so long as the saturated steam pressure of the water contained in the leaf is greater then the partial pressure of the vapor contained in the ambient air in the chamber. The greater the difference between the two pressures, the faster becomes the drying speed. On the other hand because latent heat is removed from the leaf for the evaporation of the water, it happens that the temperature of the leaf lowers during drying.

In an air circulation drying method, the humidity content of the air having once passed through the leaf layers approaches more to a saturated condition. Accordingly the air should be reheated to increase the moisture containing capacity of the air.

Accordingly if only the dehydration of the leaf is desired, all that is necessary is to change all of the air, which has passed the tobacco leaf layers and containing

a large amount of water, as by outdoor air. However, in the tobacco leaf drying process of concern, such a drying condition is also required but the tobacco leaf should be gradually dried and set while dehydration velocity and leaf is controlled so that the leaf ingredients change gradually over a long period of time.

Accordingly the amount of intake and exhaust air should be kept within 5 to 30% of the total circulated air. Thus it becomes necessary as a drying condition that most of the humid air having passed the leaf is to be reheated during the recirculation and sent into the drying chamber as a reheated hot humid air. This increases the thermal efficiency of the drying system and brings a good economic result.

Accordingly, another object of this invention is to provide a tobacco leaf drying system having an air-inlet opening and closing device which is operated independently of the wet-bulb temperature control device, and in operation, starts to open the inlet gradually when the mesophyll drying stage begins, and closes it by the end of the stem drying stage, in order to ventilate humid air having passed through the leaf layers in amount almost equal to outdoor air introduced into the chamber, so as to change slowly the mixing ratio of the taken in fresh air, thereby maintaining the chamber humidity at a proper level and advancing a successful drying.

Still another object of this invention is to provide a tobacco leaf drying system which can simplify such tobacco leaf harvesting and handling labour as the packing of the leaves at the cultivation site, transportat-

ion from the cultivation site to the site of the drying system and feeding them into the chamber without damaging the leaves, and which can dry the leaves as they are harvested, and packed thereby cutting greatly the labour content for above operations compared with a conventional harvesting handling and drying process.

Also in the present invention of the drying system, the means to pack the leaves and carry them into the system are not limited to a device which uses the above mentioned tobacco leaf storage casing.

Accordingly still another object of this invention is to provide a tobacco leaf hanging means used for the drying chamber which clamp and hang bases of the leaves.

In due consideration of the facts as set forth above, the invention contemplates the burner of the heater arranged in the tobacco leaf curing device is adapted to be automatically ignited or extinguished depending on the temperature variation appearing on the wet-bulb temperature sensor located in the curing barn according to the present invention. As a result, in accordance with the present invention, not only the first half of the tobacco leaf curing process but also the second half consisting of the leaf drying stage and the stem drying stage may be effectively controlled so as to stabilize the wet-bulb temperature always at about 38°C and the leaf curing process may be securely accomplished by the spontaneous rise of the dry-bulb temperature. The process of program control system of prior art may be thus replaced by a fully automatic drying process of an essentially improved system accor-

ding to the invention.

The inlet port control mechanism is arranged so that the inlet port is automatically opened in progressive manner as the leaf drying stage begins and is closed again before the stem drying stage is completed; that the external air of which the amount depends on the opening extent of said inlet port is sucked into the circulation duct system and the wet air which has passed through layers of tobacco leaves is automatically exhausted through the outlet port by the amount substantially corresponding to that of the external air sucked by said mechanism into the circulation duct system; and that the rate of the external air mixed into the air in said circulation duct system may be varied to increase or reduce the moisture containing capacity of the air and thereby to maintain the humidity within the curing barn most suitable for curing of tobacco leaf. Accordingly, the problems such as residue of green, coloring in brown or darkening of color may be avoided in drying the leaf and stem portion to obtain a cured leaf of high quality.

Furthermore, tobacco leaves gathered on a farm are packed into the casing body of U shape in cross section, then said body is lidded with the auxiliary plate and these casings storing therein tobacco leaves are laterally and vertically placed on the floor of the curing barn for tobacco leaf curing process according to the present invent-ion. This feature is advantageous particularly in that a series of operations such as packing tobacco leaves into the casing on the farm, transport of the casings from the farm to the curing barn and storing the casings into the curing

barn may be simplified; that tobacco leaves may be protected against breakage or damage during these operations; and that the time taken for these operations may be remarkably saved compared to the process of prior art and, as a result, the working efficiency of the curing barn and the output of tobacco leaves which have been properly processed may be improved.

The invention therefore achieves a tobacco leaf curing system comprising; an air tight curing house divided by a porous floor plate into an upper curing barn and a lower blast chamber, the curing barn being provided at its upper portion with a circulation port and an outlet port; a circulation duct passage in which air in the curing barn is sucked from said circulation duct to be compressed by duct fans and heated by a heater, then the forced and heated air is blasted into the blast chamber again through a blast port; an automatic temperatures regulator of which burner is automatically ignited or extinguished according to variation appearing on wet-bulb temperature sensor so as to regulate the temperature and humidity of the air to be sent to the blast chamber; an inlet control system comprising a cylindrical damper provided with openings and located at said circulation duct passage, and being so arranged that, with the rotation of said damper, the inlet port is automatically opened in progressive manner as the leaf setting stage begins and is closed again before the stem drying stage is completed, and that the mixing ratio of external air to forced, heated air to be supplied into the blast chamber is to be varied adjustedly at each curing stage; and an outlet port control mechanism which is loca-

ted on the outlet port opening at a side of said curing barn and automatically opened or closed according to the amount of air which is sucked through the inlet port of the inlet port control system so that the air which has passed through the curing barn may be partially exhausted through the outlet port thereof to the exterior of said barn.

The embodiments of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a perspective view showing partially in broken away a whole device;

Figure 2 is a front section of a heater arranged in a circulation duct system;

Figure 3 is a section taken along a line (a) - (a) in Figure 2;

Figure 4 is a section taken along a line (b) - (b) in Figure 3;

Figure 5 is a perspective view showing an automatic temperature regulator;

Figure 6 is a front view showing partially in broken away a wet-bulb temperature sensor;

Figure 7 is a perspective view showing partially in broken away an inlet port control mechanism;

Figure 8 is a front section showing said inlet port control mechanism;

Figure 9 is a side view showing partially in broken away a tobacco leaf storage casing;

Figure 10 is a plan view showing said storage casing;

Figures 11 and 12 are a side view and a side

section illustrating the manner of tobacco leaf packing operation;

Figure 13 is a side section showing the tobacco leaf storage casings placed on the floor of the curing barn;

Figure 14 is a front section showing collapsing manner of the tobacco leaf storage casing;

Figure 15 is a front view showing suspending clips which are carried on inner surfaces of rear portions of opposite side plates mounted on the tobacco leaf storage casing to hold the tobacco leaves which are packed into the casing body at the bases of tobacco leaves;

Figure 16 is a plan view of the suspending clips;

Figure 17 is a section taken along a line (c) - (c);

Figure 18 is a side section showing the suspending clips as being closed;

Figure 19 is a clip of Figure 18 opened;

Figure 20 is a front view of a binder;

Figure 21 is a plan view of said binder;

Figure 22 is a section taken along a line (e) - (e) showing the binder as holding tobacco leaves;

Figure 23 is a side section showing the binder as being dismantled; and

Figure 24 is a standard curing chart.

Referring to Figure 1, a curing or drying house (A) is an assembly type air tight shed, constructed on a water proof and heat-insulated base (40), with frames (41) and wall panels (42) made of metal plate or insulation mat-

erial. A floor plate (2) provided with a number of small holes is installed at the lower part inside the shed. A drying chamber or curing barn (3) is formed above said plate (2) and a blast chamber (4) below the floor (2).

A door is provided at a sidewall opposite to a side wall behind which is provided air circulation duct passage (B). When the door is opened, tobacco leaf storing casing (F), leaf container, packed with tobacco leaves or tobacco leaf hanging bars (G) clamping tobacco leaves are carried in and out. The side walls and the door are provided at proper points with observation windows (43) (43) permitting easy observation of the change of the tobacco leaves during curing process.

The curing barn (3) is an air tight space for drying or curing tobacco leaves (H), which are stored in tobacco leaf storage casings piled on the perforated floor (2) or hung by hanging bars (G), by forced and heated air supplied from the blast chamber (4), passing through the small holes (1) (1).. and injecting into the barn (3). The curing barn (3) is provided at the upper part of any desired one side wall with air circulation port (5) for sucking humid air having passed layers of tobacco leaves (H) into the air circulation duct system (B). While outlet port (14) is provided at a proper point of any desired wall for exhausting to the outside a part of human air which have passed the tobacco leaves (H).

Referring to Figures 1 and 4, a blast chamber (4) disperses uniformly the forced heated air sent thereinto from air circulation duct passage (B) through blast port (8), and feed the air into the curing barn (3) at an

uniform temperature through the small holes (1) (1) of the floor (2).

The porous floor plate (2) is constituted of steel or plastic plate provided with many small holes across all over the plate or is constituted of a net plate. The plate is installed slightly above the blast port (8), thus partitioning the inside space of the curing barn (A) into an upperpart which is used as a drying or curing barn (3) and a lower part which is used as a blast chamber (4). Baffle plates (44) (44)..are erected below the floor (2) and at right angle to the advancing direction of the heated air sent from the blast feed port (8).

Baffle plates (44) are provided with many small openings (45). The top margin of the plate (44) is bent to form a hook (44'). The plates are inserted through a long slot provided in the floor (2) so that the plate hang from the floor (2) into the blast chamber. The length of the baffle plates becomes greater as they come apart from the blast feed port (8) so that the blast chamber may function as a floor duct. That is, the heated blast, passing through the small holes (45) (45) of plates (44) (44), are supplied to the curing barn (3), with equal volume even at a remotest place from the blast port (8).

The circulation duct mechanism (B) is an air tight ventilation passage extending from the air circulation port (5) provided in a wall of the blast chamber (4). The passage (B) is provided with: a duct fan (6) which sucks air from the curing chamber (3) through the air circulation port (5) and compresses the sucked air; a heater (7) which heats the sucked air; an inlet port automatic

control system (D), provided between the air circulation port (5) and the duct fan (6) and sucks external air so as to change the mixing ratio of the external air to the circulating air: and a blast distribution chamber (32) constructed to send above forced and heated air uniformly to the blast chamber (4) through the blast feed port (8).

Referring to Figures 2, 3 and 4 the air circulation duct passage (B) consists of a blast distribution chamber (32) and a sealed compartment which is positioned on and connected to the distribution chamber (32). The compartment is constructed as a hollow box shape by panels. The sealed compartment is divided into an upper and a lower chambers by a partition plate (46) set horizontally. The upper chamber is connected to the lower chamber through the duct fans (6) (6) secured on the partion plate (46). The upper chamber is connected to the air circulation port (5) provided at the place facing the curing barn (3), while the lower chamber is used as a heat exchanging room (47) housed with a heater (7) and connected at its bottom with the blast distribution chamber (32).

The heater (7) consists of a burning furnace (48) and its heat source, i.e. a burner (24) both housed in the heat exchange room (47).

The burning furnace (48) is provided with a design employing a specially contrived furnace shape and a special flue pipe connection system, which will increase the heat exchange efficiency between the heated air and the circulating air to be heated. The burner (24) is ignited automatically by a signal generated by an automatic temperature control system (C).

The circulation air sucked into the heat exchange chamber (47) by the duct fans (6) is heated in the chamber (47) and fed into the blast distribution chamber (32) below the exchange chamber (47).

In order to send the forced, heated air from the blast distribution chamber to the blast chamber (4) uniformly through the blast port (8), the distribution chamber (32) is either provided with appropriate number of blast guide plates (56)(56) arranged parallel to the direction of the blast port (8), or opened at a whole one side and to connect with the blast port (8).

Referring to Figures 1 and 7, the inlet port control system (D), installed in the duct passage between the air circulation port (5) of the air circulation duct passage (B) and the duct fan (6), sucks external air and changes the mixing ratio of the circulating air. An inlet port (10) is provided in the upper surface of the sealed compartment composing the circulation duct passage (B).

And a cylindrical hollow drum (26) is installed laterally in said air inlet port (10), while air passage openings (27)(28) are provided in the circumferential wall of said drum so as to communicate the inside of the circulation duct (B) with external air, and a damper (11) is slidably fitted in the drum (26).

The damper (11) is cylindrical, a little smaller than the hollow drum (26) in diameter, and slides on the inside surface of the drum (26). -The damper (11) is provided with rectangular holes (12)(13) at its body portion and rotated by a motor (30) via speed reduction device (72).

The damper (11) may be made of two same arc

shaped plates positioned to face with each other, with both ends secured to discs (73) (73) and to have air passage holes (12) (13) located vertically. Anyway, the damper (11) must be so constructed that vertical air passages (27) (28) of the hollow drun (26) are opened and closed by movement of the surface and air passage hole (12) (13) of the damper, and thus opening and closing of the inlet port (10) is assured.

Further, the damper (11) is connected electrically to automatic control means (see figure 1) which generates an electric signal at predetermined intervals, causing the motor (30) to be rotated, and slightly rotates the damper to open the inlet port (10) in progressive manner.

The drum (26) is envelopped with a cover such as a net plate so as to prevent foreign matter from entering into the circulation duct (B) from inlet port (10).

The automatic control means (74) generates an electric signal at predetermined intervals, during mesophyll or leaf setting and stem curing stage, causing the electric motor (30) to be rotated for the seconds defined by the timer to which said signal is applied, slightly rotating the damper (11) to open the inlet port (10) in a progressive manner. That is, the damper moves slowly to the fully opened position as the leaf setting stage progresses, and moves again to the a rather closed position by the time when the stem curing stage starts, and stops at an almost closed position in the leaf curing stage to suck but a small amount of external air. During which period, the mixing ratio is changed to external air in the forced, heated air stream which should be sent into the blast chamber (4).

Referring to figures 5 and 6 the automatic temperature regulator system (C) comprises a heater (7) arranged in said circulation duct system (B), a wet-bulb temperature sensor (9) and an automatic temperature regulator (23) adapted to be operated according to indication of said sensor (9).

The wet-bulb temperature sensor (9) comprises an evaporation water tank, a reservoir (25) adapted to supply said water tank (21) with water so that said tank may be always filled with water to a predetermined level and said regulator (23) enveloped by a piece of cloth which is partially dipped into said water tank (21).

The reservoir (25) includes a cover (56) threaded into upper portion thereof and a water pipe (57) and an air duct (58) of different lengths respectively depending therfrom in unison therewith. An additional duct (59) is connected with said air duct (58) and upper end (59) of said duct (59) is supported within the reservoir (25) at upper portion thereof. A stem member (60) of a suitable length is inserted into said water pipe (57) in vertically movable manner and provided at its upper end with a valve of material such as rubber or synthetic resin which is substantially inverted cup shaped while at its lower end with a weight fixed thereto. The water pipe (57) and the air duct (58) are removably inserted into respective receiving openings (63) and (64).

The evaporation water tank (21) is arranged in the form of offset tank and includes an upper cover plate (21') provided with said receiving openings (63)and (64) into which said water pipe (57) and the air duct (58) of the reservoir (25) are snugly inserted and a lower cover

plate (21"), on upper surface of which, a pair of temperature sensors (33) and (66) are fixedly mounted. The piece of cloth (31) such as cotton cloth or gauze enclosing the periphery of one of said temperature sensors (33) is partially dipped through a slit (65) extending through lower portion of said sensor (33) into the water so that this sensor (33) actually serves as the wet-bulb temperature sensor (9) and the other sensor (66) serves as a dry-bulb thermometer of monitoring.

In supply of water into said reservoir (25), therefore, removal of said reservoir (25) from the evaporation water tank (21) causes the valve (61) to close the water pipe (57) in an automatic manner under gravity of the weight (62) and further supply of water would cause no overflow of excessive water from said reservoir (25). As the reservoir (25) is assembled again on the water tank (21) through operation of its insertion into the receiving openings (63) and (64) of said water tank (21). The lower end of the stem member (60) bears against bottom surface of the water tank (21) and thereby forces the valve (61) upward so that water in the reservoir (25) may be introduced through the water pipe (57) into the water tank (21) and water may be maintained at a level such that the air duct is effectively sealed.

Said wet-bulb temperature sensor (9) and said dry-bulb thermometer (66) respectively include electrical temperature detector members such as thermoelectric couples, thermometric resistors or thermistors and the thermal variation detected by these detector members is transmitted to the automatic temperature regulator (23).

The automatic temperature regulator (23) indicates on a temperature indicator (68) variation appearing on said wet-bulb temperature sensor (9) and said dry-bulb thermometer (66) through operation of a dry-and wet-bulb temperature indication change-over switch (67) and sets the wet-bulb temperature within the curing barn by operation of a temperature setting knob (70) of an electronic temperature regulator (69). Said electronic temperature regulator (69) is electrically connected to the burner (24) of the heater (7) so that said burner (24) may be automatically ignited or estinguished according to variation appearing on said wet-bulb temperature sensor (9).

The automatic temperature regulator (23) is further provided with the duct fan (6) and a burner ignition switch (71) operation of which causes rotation of said duct fan (6) arranged in the circulation duct system (B) and ignition of said burner (24).

Referring to figure 1 the outlet port control mechanism (E) is located on the outlet port (14) opening at a side of said curing barn (3) and automatically opened or closed according to the amount of air which is sucked through the inlet port (10) of the inlet port control system (D) so that the air which has passed through the curing barn (3) may be partially exhausted through the outlet prot (14) thereof to the exterior of said barn. This mechanism (E) assumes the form of a duct in which a pivot (76) is horizontally suspended at a lower portion of said duct and the lower end of the control plate (34) is fixed on this pivot (76). A balance weight is mounted on the other end (77) of said plate (34) so that said plate (34) may be normally

held raised under gravity of said balance weight to close the outlet prot (14).

When the inlet port control system (D) sucks the external air, however, the pressure of circulating air excesses the atmospheric air by the amount of thus sucked air and this pressure difference causes the control plate (34) to be opened with a result that the wet air in the curing barn (3) is exhausted to regulate the moisture content in the circulating air.

Now referring as well to figures 10 through 12 the tobacco leaf storage casing (F) comprises the body (15) and the auxiliary plate (20) both of material such as synthetic resin or metal.

The body (15) comprises a bottom plate (39) and side plates (36) (36) collapsibly supported on pivots (78) arranged on opposite side edges of said bottom plate (39), respectively, and this body (15) has a U shape in cross-section when said side plates take their raised positions.

Each of the side plates (36) (36) is provided at rear portion (16) with an opening (18) into which a locking projection (79) of the auxiliary plate (20) is engaged and thereby the latter is removably secured to the respective side plate. Each of the side plates (36) (36) is further provided at upper portion (18) with a locking hook (19a) adapted to be engaged into a groove (81) of the auxiliary plate (20) including a pawl (80), an opening (19 b) into which said locking projection (79) of said auxiliary plate (20) is engaged and retractable locking means (82).

Thus, the auxiliary plate (20) has, in addition

to said locking projection (79) adapted to be engaged not only into the opening (18) in the rear portion (16) of said each side plate (36) (36) but also into the other opening (19 b) in the upper portion (17) thereof, the groove (81) into which the locking hook (19 a) on the upper portion (17) of the side plate (36) and the pawl (80) included in said groove (81) so that the auxiliary plate (20) may be remobably engaged with the rear and upper surfaces of the body (5).

Each of the side plated (36) (36) is further provided in inner surface of the rear portion thereof with a guide groove (84) for removably carrying a suspending clip (37).

Referring to figures 15 through 19 the suspending clip (37) comprises a pair of holdding plates (85) (85') made of synthetic resin or metallic material opposed to each other as the flats of the hands being joined, a substantially hinge-shaped spring (38) provided between the both holding plates (85) (85') with both ends of said spring fixed to the respective ones of said holding plates so that these holding plates (85) (85') may be connected to each other in the form of a hinge and normally opened under effect of the spring (38).

One of the holding plate (85) is provided with a locking piece (86) to hold the both holding plates (85) (85') as joined flats of the hands against the effect of the spring (38').

The locking piece (86) is formed from a single metallic bar having a satisfactory elasticity which is suitably bent with one end passed through the other

holding plate (85') and anchored thereon and the other end or a locking portion (86') so shaped that the latter extends above the holding plate (85) and is disengagably engaged thereon.

To increase contact resistance between the bases (H') of tobacco leaves (H) packed in the body (15) and the suspending clip (37), clipping coils (88) (88) extend through a plurality of holder means (87) along the surfaces of both holding plates (85) (85).

The means to load said tobacco leaves (H) into the curing barn (3) is not limited to utilization of said tobacco leaf storage casting (F) but it is also possible, as will be described more in detail, to suspend tobacco leaves with their bases (H') held by the binder (G) on supports (101) fixed on side-walls in the curing barn (3).

Referring to figures 20 and 21 the binder (G) comprises a core (92) including a sponge bar (90) and support plates (91) (91) carried by said sponge bar on opposite sides thereof, holders (93) (93) removably provided in opposed to the respective ones of said support plates (91) (91), and suspenders (94) (94') fixed on outer sides of said support plates (91) (91) and to inner sides of said holders (93) (93) respectively.

The sponge bar (90) may be of suitable foaming material having a resiliency which has been formed substantially in a band and carries the support plates (91) (91) on opposite sides and is held by resilient bars (95) (95) between both support plates (91) (91).

The suspenders (94) (94') comprise coils of iron wire which are expanded and mounted by hooks (96) (96)

on outer sides of the support plates (91) (91) and on inner sides of the holders (93) (93), respectively.

One of the holders includes a grasper (97) having a ⊔ shape in cross section which is, in turn provided at an end with detachable locking hooks (98) and locking bars (99) pivotally mounted on opposite side edges so as to be engaged into respective notches (100).

Now referring to figures 22 and 23 as well tobacco leaves (H) are laterally suspended within the curing barn on the supports (101) with the bases (H') of tobacco leaves being held between the suspenders (94) (94') mounted on thus arranged support plates (91) and holders (93).

The manner in which the device is utilized according to the present invention will now be described with respect to the case in which the tobacco leaf storage casing (F) are stored. Initially for storage of tobacco leaves (H) gathered in a farm into the tobacco leaf storage casing (F), the side plates (36) (36) thereof being initially collapsed onto the bottom plate (39) they are raised and the auxilliary plate (20) is engaged into the rear portion (16) thereof as shown by Figs. 9, 10 and 14. Thereafter the bases (H') of tobacco leaves (H) are aligned by bearing them against the front surface of the auxiliary plate (20) as seen in Fig. 11 and successively piled. Both ends (89) (89) of the suspending clips (37) are engaged into the guide grooves (84) provided in the both side plates (36) (36) and tobacco leaves (H) are successively piled together with the suspending clips (37) in alternate manner.

Upon completion of the leaf packing operation

as above mentioned, the auxiliary palte (20) is removed from the rear portion (16) of the body (15) and then engaged into the upper portion (17) of said body (15). Thereafter, the locking bar (86) of the suspending clip (37) is disengaged so that the holding plates (85) (85') of said suspending clip (37) may be opened under the effect of the spring and the bases (H') of tobacco leaves (H) packed into the body (15) may be tightly clipped.

The tobacco leaf storage casings (F) thus containing therein tobacco leaves (H) are transported by means such as an autotruck from the farm to a curing house (A) and placed laterally and vertically on the floor (2) of the curing barn (3) with the bases (H') of tobacco leaves (H) being directed upward.

The switch (71) of the automatic temperature regulator (23) is now closed to rotate the duct fan (6) and to ignite the burner (24). The temperature setting knob (70) of the electronic temperature regulator (69) which is associated with said regulator (23) is set to the desired temperature (i.e., the wet-bulb temperature 38°C) to operate the burner (24) and ehereafter the burner (24) itself is automatically ignited when the temperature indication of the wet-bulb temperature sensor (9) is lower than that set by the automatic temperature regulator (23) while automatically extinguished when said temperature indication is higher than that set by the automatic temperature regulator (23), maintaining the wet-bulb temperature within the curing barn (3) at 38°C.

Rotation of said duct fan (6) causes the air within the curing barn (3) to be sucked through the circul-

ation port (5) into the circulation duct system (B). The air gets its preasure increased by the duct fan (6) and is heated by the heater (7), then introduced from the air distribution chamber (32) through the blast port (8) into the blast chamber (4). Then the air rises through a whole surface of the porous floor plate (2) toward upper portion of the curing barn (3) at an even temperature, heating or curing tobacco leaves (h) during passing through tobacco leaves (H) within the storage casing (F), and is sucked and circulated again by the duct fan (6).

As earlier mentioned, the curing process is usually divided for convenience into the first half period comprising the preheating stage for fermentation and the yellow coloring stage and the second half period comprising the leaf drying stage and the stem drying stage. Now, the cruing process will still be described in accordance with such a sequence.

The pre-heating stage for fermentation is started by ignition and heating with the window (43) (43) .... and the doors tightly closed. The purpose of this fermentation stage is to increase the leaf temperature and thereby to facilitate the next coloring stage. Substantially 5% of moisture content in tobacco leaf is removed during this fermentation stage.

The coloring phase is most important in acceleration of curing and chemical change of ingredients which results in the phenomenon of coloring. During this stage, desiccation is intended while the temperature and the amount of oxygen are maintained best suited for respiration. A principal purpose of this coloring stage is to increase

the leaf temperature and thereby to facilitate respiration by circulation of hot air at high humidity. The hot air at high humidity has a heat quantity enough to control desiccation of tobacco leaf temperature. The leaf temperature thus increased facilitates a respiratory action and accelerates coloring. Substantially 20% of moisture content in tobacco leaves is further removed during this coloring stage.

The leaf drying stage is the stage during which the curing has substantially been completed and the drying or desiccation begins. Purpose of this stage is to color the residual green in stem and to perfect desiccation in the leaf which has already been colored to the extent such that said leaf portion is dried in bright yellow. Depending upon the manner of processing during this stage, there may occur a resudue of green, coloring in brown or darkening of color.

To avoid the problems such as darkening of color,it is desired that withering of cells and desiccation should simutaneously take place. Such a requirement is satisfied as described below according to the present invention.

From the moment at which the process has transferred to the leaf drying stage, the automatic control means (74) included in the inlet port control mechanism (D) generates an electric signal at predetermined intervals, causing the electric motor (30) to be rotated for the seconds defined by the timer to which said electric signal is applied, and slightly rotates the damper (11) to open the inlet port (10) in progressive manner. The external

air is sucked through said inlet port (10) under the sucking effect of the duct fan (6) into the circulation duct system (B), the amount of thus sucked air depending upon the opening extent of said inlet port (10), and the ratio of said external air mixed into the air within the system is varied to increase the moisture containing capacity of the air and to accelerate the desiccation of tobacco leaves.

The wet air which has passed through the layers of tobacco leaves (H) is automatically exhausted through the outlet port (14) by the amount substantially corresponding to that of the external air which has been sucked by the mechanism(D).

The mechanism (D) is prest so that the inlet port (10) and the outlet port (14) are fully opened when the dry-bulb temperature of approximately 45°C is reached. Although the true drying process begins at this moment, leaf desiccation has already been accomplished to the extent sufficient to initiate so-called falling rate drying phase, so that the opening extent of the inlet port (10) is now reduced again to increase a thermal efficeincy and to accelerate the inner diffusion of moisture residue in leaves at higher temperature. Approximately 60% of moisture content in tobacco leaves is further removed during this leaf drying stage.

Tobacco leaves have now already been cured except the stem portion which remains undried through the stages prior to the stem drying stage. In view of the fact that the stem portion has its tissue more compact and tight than that of the leaf portion and, as a result, the inner

moisture diffusion is relatively slow, this stage requires a high temperature in order of 70°C to increase the drying effect. Need for ventilation is not so serious during this stage, since there is only a small amount of moisture to be evaporated. Consequently, the inlet port (10) is progressively moved to the fully closed position at this stage and the dry-bulb temperature now rises by the heat quantity that would be lost as the latent heat for gasification in the previous stages. Thus, so-called spontaneous rise of temperature effects drying until the moisture content of tobacco leaves is sufficiently removed to complete the curing of tobacco leaves (H).

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A tobacco leaf curing system comprising; an air tight curing house divided by a porous floor plate into an upper curing barn and a lower blast chamber, the curing barn being provided at its upper portion with a circulation port and an outlet port; a circulation duct passage in which air in the curing barn is sucked from said circulation port to be compressed by duct fans and heated by a heater, then the forced and heated air is blasted into the blast chamber again through a blast port; an automatic temperatures regulator including a wet-bulb temperature sensor located at the forced, heated air inlet side of the curing barn, a heater and an automatic temperature regulator adapted to be operated according to indication of said sensor, a burner and means to automatically ignite or extinguish the burner according to the variation appearing on the wet-bulb temperature sensor so as to regulate the temperature and humidity of the air to be sent to the blast chamber; an inlet control system comprising a cylindrical damper provided with openings and located at said circulation duct passage, and being so arranged that, with the rotation of said damper, the inlet port is automatically opened in progressive manner as the leaf setting stage begins and is closed again before the stem drying stage is completed, and that the mixing ratio of external air to forced, heated air to be supplied into the blast chamber is to be variably adjusted at each curing stage; and an outlet port control mechanism which is located on the outlet port opening at a side of said curing barn and automatically opened or closed according to the amount of air which is sucked through the inlet

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port of the inlet port control system so that the air which has passed through the curing barn may be partially exhausted through the outlet port thereof to the exterior of said barn.

2. Tobacco leaf curing system according to claim 1, in which the wet-bulb temperature sensor including an evaporation water tank and a reservoir adapted to supply said water tank with water so that said tank may be always filled with water to a predetermined level.

3. Tobacco leaf curing system according to claim 1, in which, a hollow cylindrical drum is installed laterally at the inlet port of the air circulation duct passage, provided with openings at its circumferential wall so as to communicate the inside of circulation duct with exterior air, and a damper is slidably and rotatably inserted onto the drum, and the damper is provided with openings capable of opening and closing the drum openings, and the rotation axis of the damper being made to be rotated by the rotation of a motor.

4. Tobacco leaf curing system according to claim 1, in which, in curing barn, harvested tobacco leaves are packed in rectangular shaped storage casings arranged on opposite sides of floor plate, or the leaves are held with their bases by leaf hanging bars on supports fixed on both sides of the walls in the barn.

5. Tobacco leaf curing system according to claim 4, having storage casing in a U shape in cross section and being provided with locking hooks to which auxiliary plates can be detachably fixed, and harvested leaves in a field can be packed therein as they are for curing in the curing barn.

6. Tobacco leaf curing system according to claim 4, in which, each of side plates of the U shaped casing is fitted

in inner surface of the rear portion thereof with suspender clips which open under effect of spring so as to hold stem base portions of packed tabacco leaves, thus enabling to hold tobacco leaves in suspended condition.

7. Tobacco curing systems as claimed in claim 4 in which a leaf hanging bar comprises a core including a sponge bar and support plates carried by said bar on opposite sides thereof, holders removably provided in opposed to the respective ones of said plates, and suspenders fixed on outer sides of the plates and to inner sides of the holders, respectively, and holds stem bases of leaves between the bar and suspenders so that the leaf hanging bar clamping the leaves can be hung on hooks secured to both side walls in the barn.

8. A tobacco leaf curing plant for processing tobacco leaves which comprises a substantially air-tight curing barn divided by a porous floor plate into an upper drying chamber adapted to house the tobacco leaves and a lower air chamber, a circulation duct passageway containing fan means and the heating means, an air circulation port means providing communication between one end of the circulation duct passageway and the drying chamber for drawing air from the drying chamber, and a distribution chamber disposed at the other end of the circulation duct passageway, said distribution chamber providing communication between said other end of the circulation duct passageway and the lower air chamber for introducing air compressed by said fan means and heated by said heating means into said lower air chamber, an ambient air inlet port with an automatic inlet port control means for controlling the amount of ambient air drawn from the atmosphere through the inlet port and introduced into the air circulation duct passageway so as

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to change the mixing ratio of the ambient air to the circulating air being supplied to the lower air chamber, an automatic temperature regulator connected to the fan means and the heating means and a wet bulb temperature sensor connected to the automatic temperature regulator, said temperature regulator adjusting the heating means according to variations appearing on the web bulb temperature sensor, thereby regulating and maintaining the temperature and humidity of the air sent to the lower air chamber at a fixed predetermined level, and an outlet port means disposed in the wall of the drying chamber for exhausting a portion of the air from the drying chamber to the atmosphere, said outlet port means being provided with a control plate associated therewith, and means for opening or closing the outlet port means depending upon the pressure differential between the circulating air inside the drying chamber and the atmospheric air.

9. The tobacco leaf curing plate of claim 8 wherein a plurality of porous baffle plates extend substantially perpendicularly from the porous floor plate into the lower air chamber.

10. The tobacco leaf curing plant of claim 9, wherein the length with which the baffle plates extend from the porous floor plate progressively increases as said baffle plates are further removed from the distribution chamber.

11. The tobacco leaf curing plant of claim 8, wherein the ambient air inlet port containing the automatic control system is disposed between the air circulation port means and the fan means.

12. The tobacco leaf curing plant of claim 8 wherein the air circulation duct passageway is divided by partition means into an upper fan chamber and a lower heating chamber, said upper fan chamber containing the fan means

and said lower heating chamber containing the heating means, said upper fan chamber communicating with the drying chamber through said air circulation port means and said upper fan chamber communicating with said lower heating chamber through said fan means mounted in the partition means.

13. The tobacco leaf curing plant of claim 12, wherein the distribution chamber provides communication between the heating chamber and the lower air chamber, said distribution chamber being provided with a plurality of guide plates arranged substantially parallel to each other for directing the heated air uniformally through the air chamber.

14. The tobacco leaf curing plant of claim 1, wherein the ambient air inlet port is provided in the fan chamber and said automatic control system is installed in the inlet port and comprises a hollow cylindrical drum containing opposing air passage openings in its circumferential wall thereby providing communication between the fan chamber and the atmosphere through said inlet port and a damper means slidably disposed within said cylindrical drum, said damper means being provided with motor means for rotating said damper means to open and close the opposing air passage openings and thus the ambient air inlet port.

15. The tobacco leaf curing plant of claim 14, wherein the damper is electrically connected to automatic control means which generates an electrical signal at predetermined intervals for controlling the angular position of said damper.

16. The tobacco leaf curing plant of claim 8, wherein the wet bulb temperature sensor is located at the forced, heated air inlet side of the drying chamber.

17. The tobacco leaf curing plant of claim 16, wherein the wet bulb temperature sensor includes an evaporation water tank, a reservoir adapted to supply said water tank with water, and including means whereby said tank is filled to a predetermined level, said temperature sensor being enveloped by a piece of cloth which is partially disposed in the water.

18. The tobacco leaf curing plant of claim 8, wherein storage casings are disposed on opposite sides of the porous floor plate and the tobacco leaves are packed in said storage casings.

19. The tobacco leaf curing plant of claim 8, wherein the drying chamber contains side walls and support members are fixed to said side walls said support members being provided with leaf hanging bars which hold the tobacco leaves by their bases.

20. The tobacco leaf curing plant of claim 8, wherein the storage casings have a U-shaped cross-section provided with front and rear portions, said casings containing locking hooks with auxiliary plates detachably fixed thereto, said casings being adapted to be packed in the field with tobacco leaves for curing in the leaf curing plant.

21. The tobacco leaf curing plant according to claim 20, wherein each of the side plates of the U-shaped casing is fitted in the inner surface of the rear portion thereof with suspender clips which open under spring pressure, hereby holding the stem base portions of the tobacco leaves in a suspended state.

22. The tobacco leaf curing plant of claim 19 wherein the hanging bars comprise a core including a sponge bar, support plates carried by said bar on opposite sides thereof, holders removably provided in opposition to the respective ones of said plates, said suspenders fixed to the outer

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sides of the plates and to the inner sides of the holders, respectively, the stem bases of said leaves being held between the bar and suspenders so that the leaf hanging bars clamping the leaves can be hung on hooks secured to both sides of the leaf curing plant.

23. The tobacco leaf curing plant of claim 8, wherein the heating means is a heat exchange device provided with a burner, said temperature regulator being connected to said burner.

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FIG. I

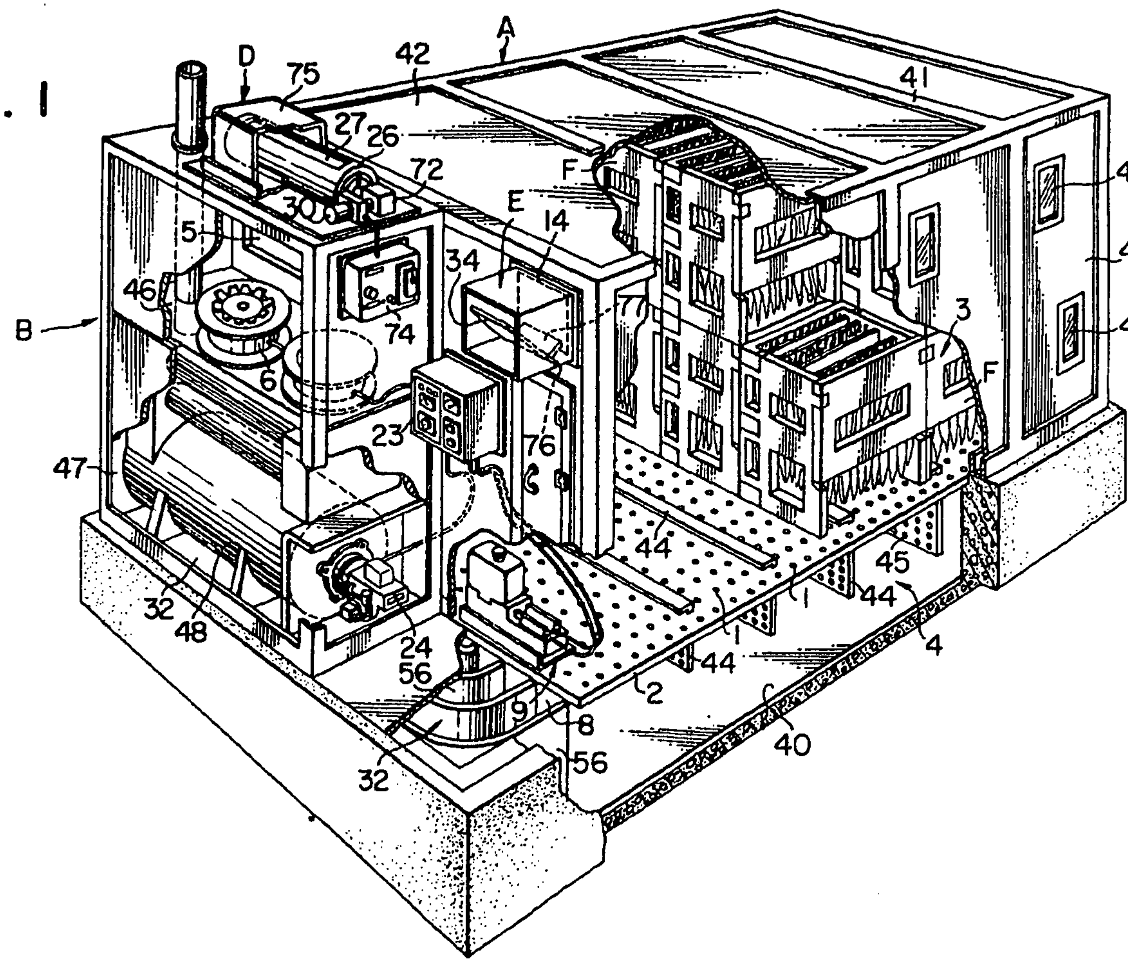

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FIG. 2

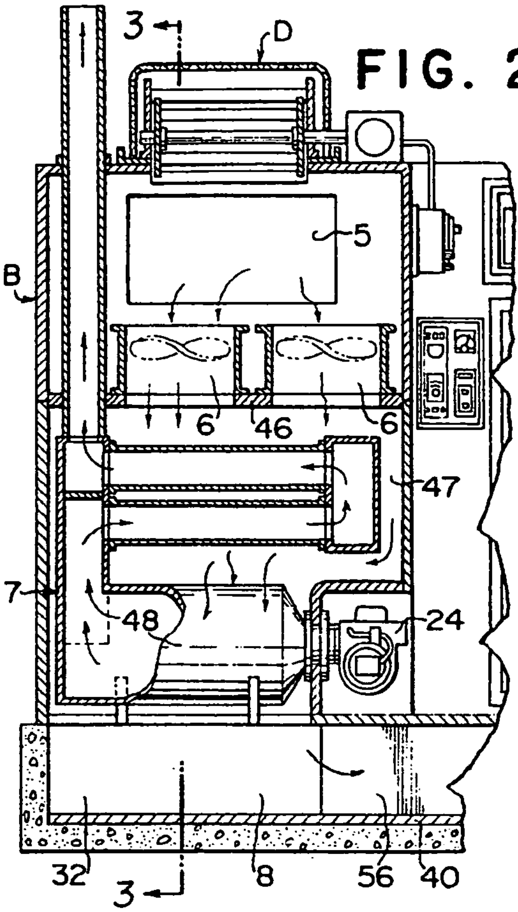

FIG. 3

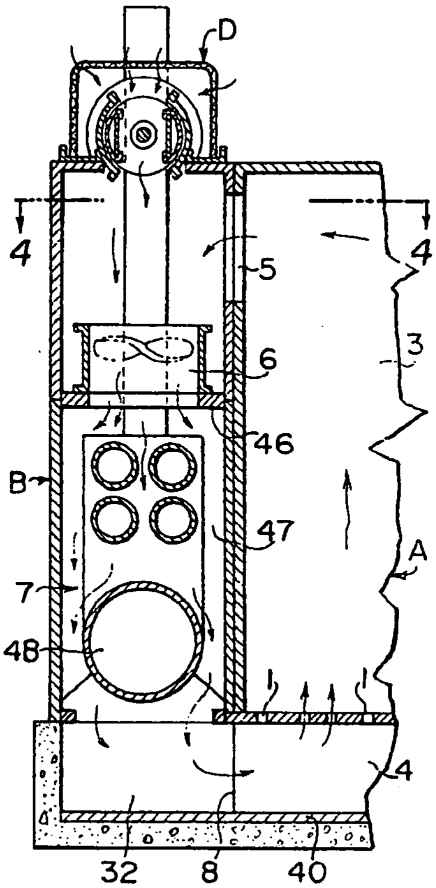

FIG. 4

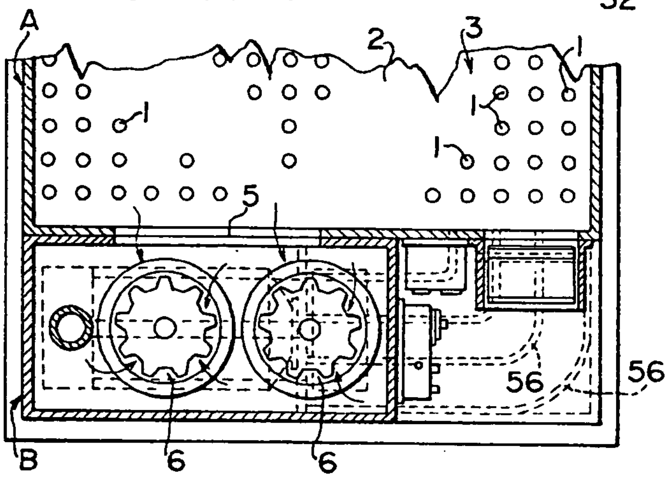

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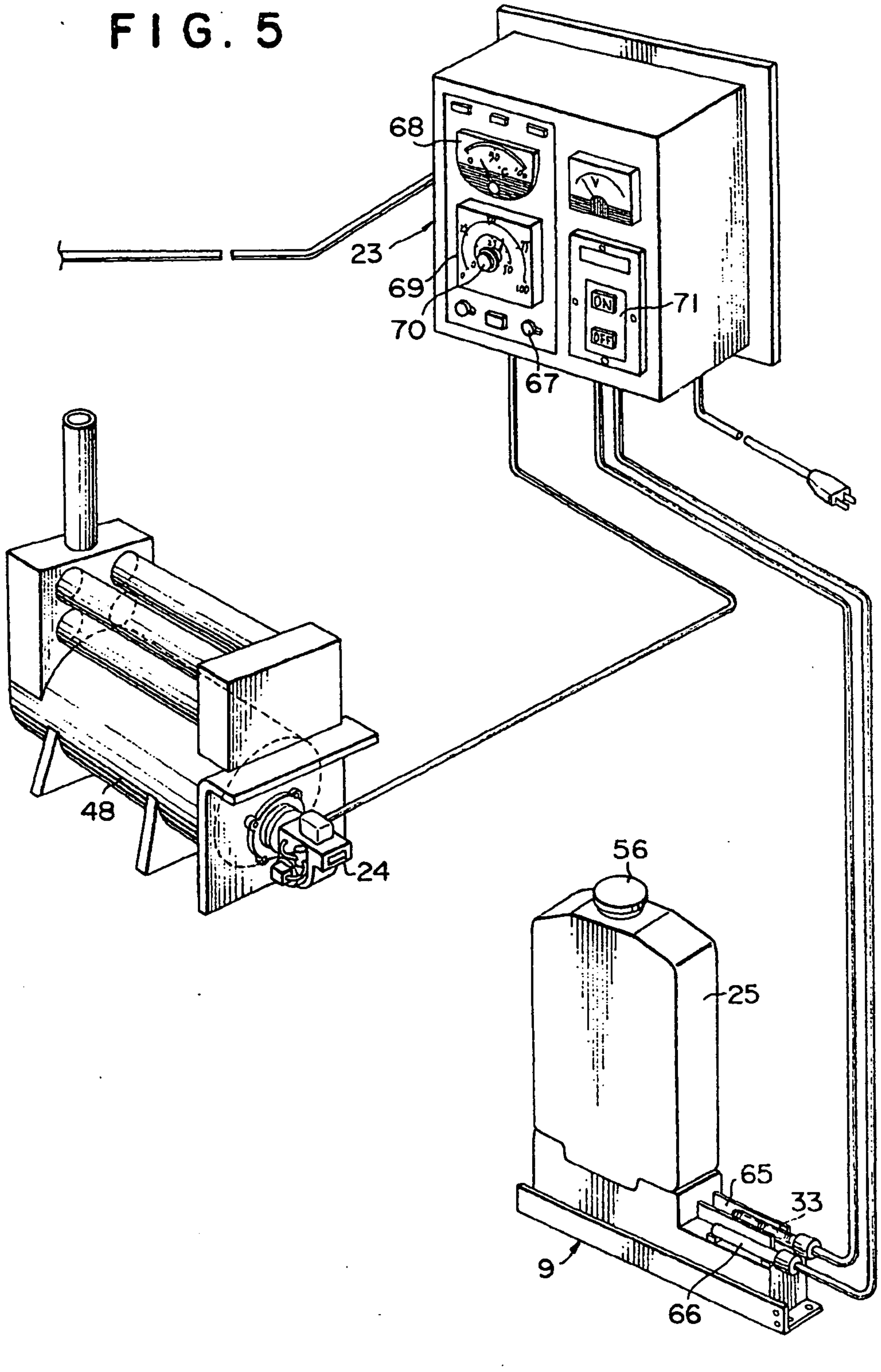
FIG. 5



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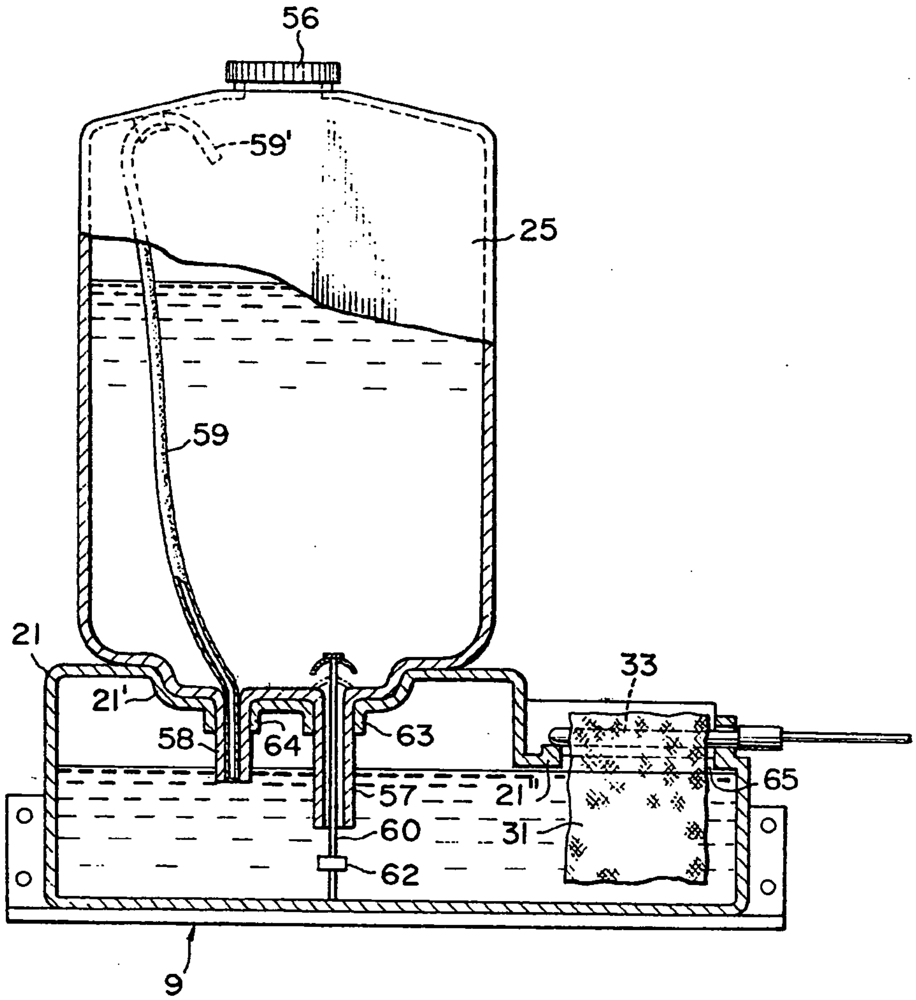

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FIG. 7

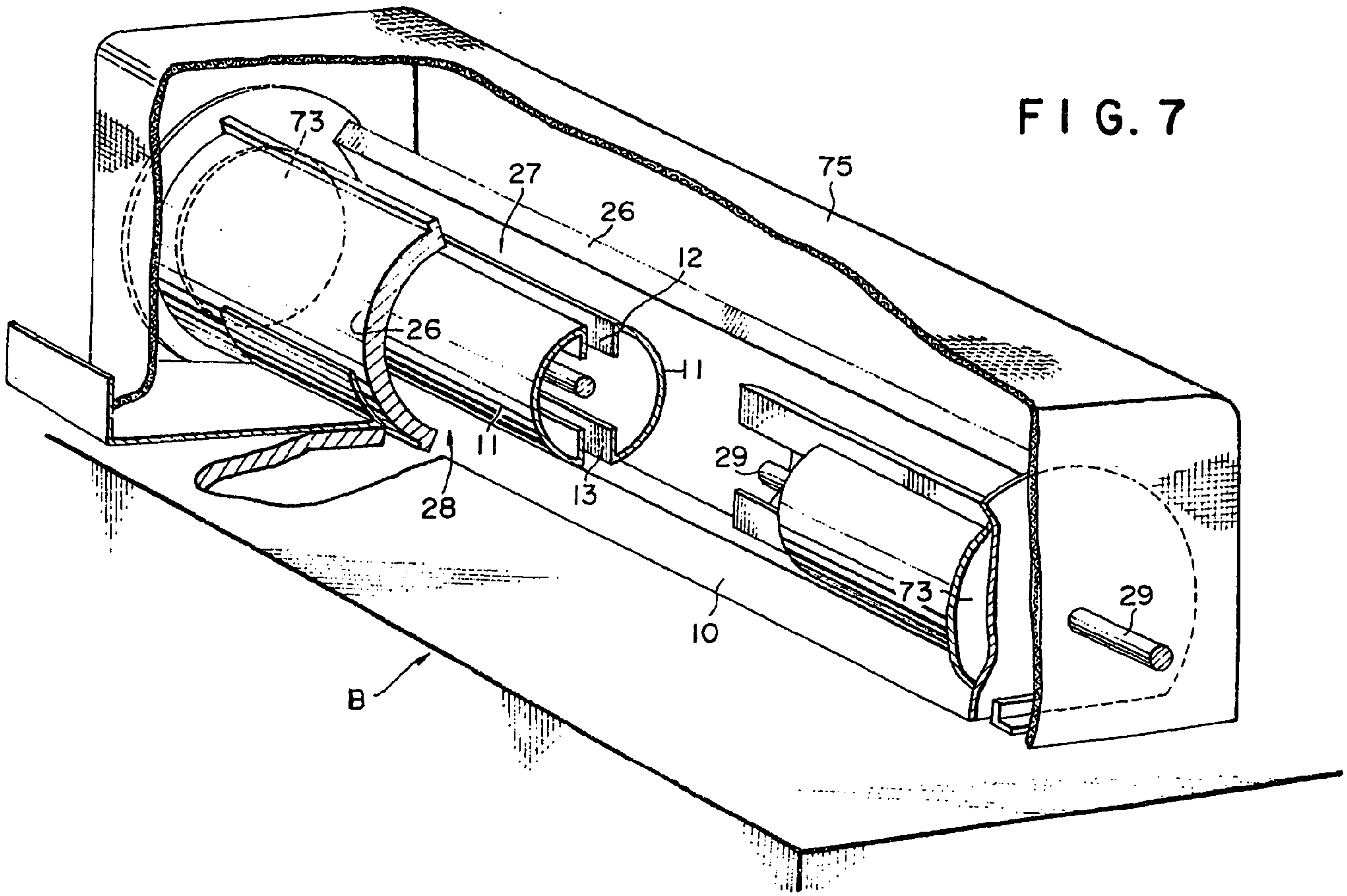

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FIG. 8

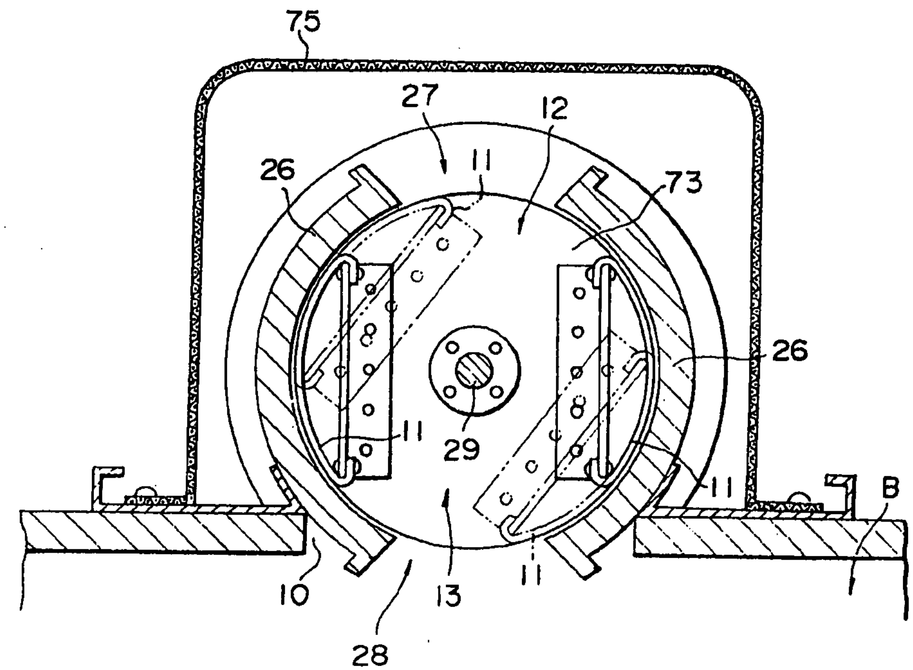

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FIG. 9

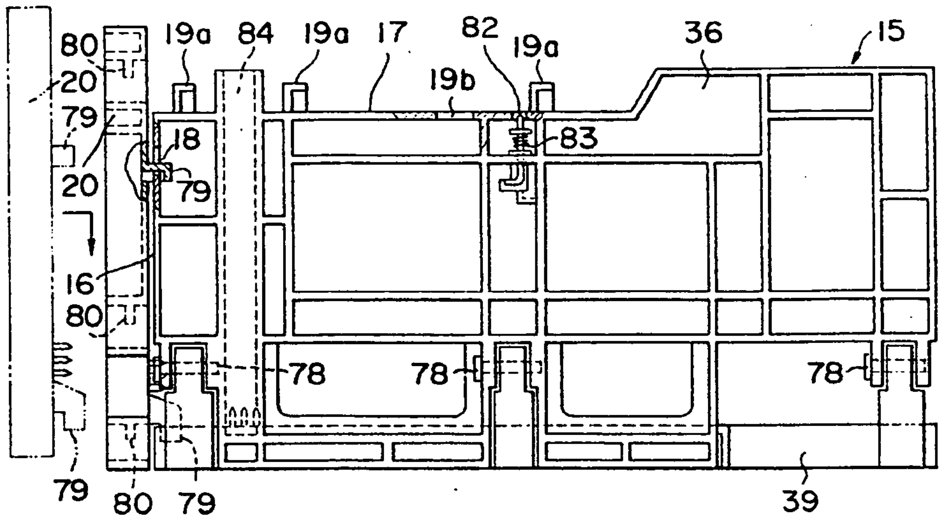

FIG. 10

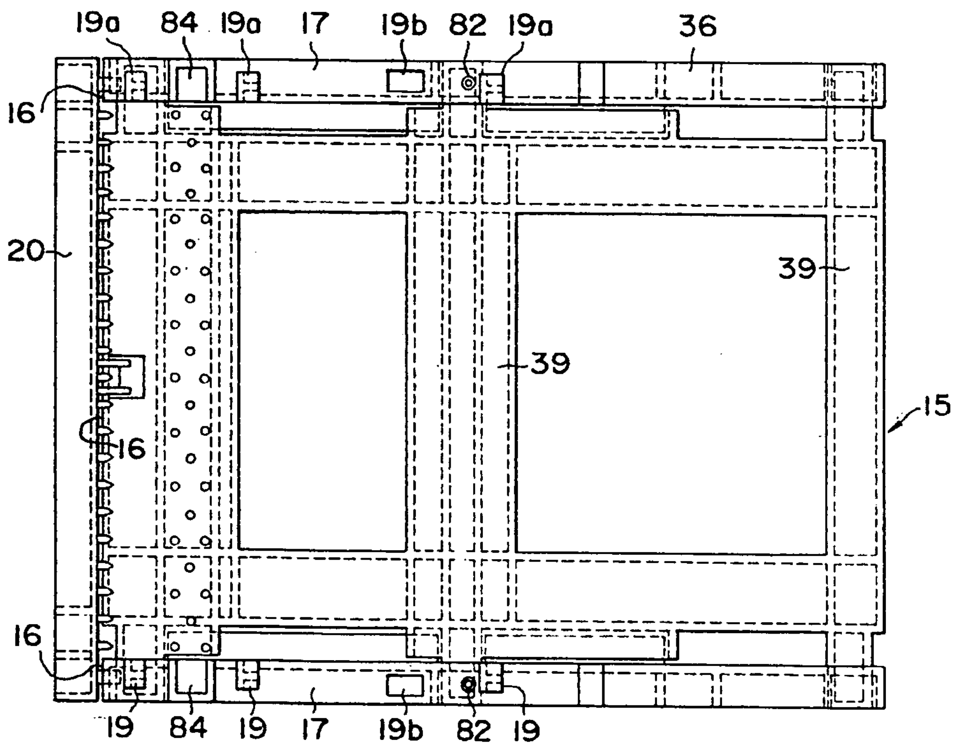

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FIG. 11

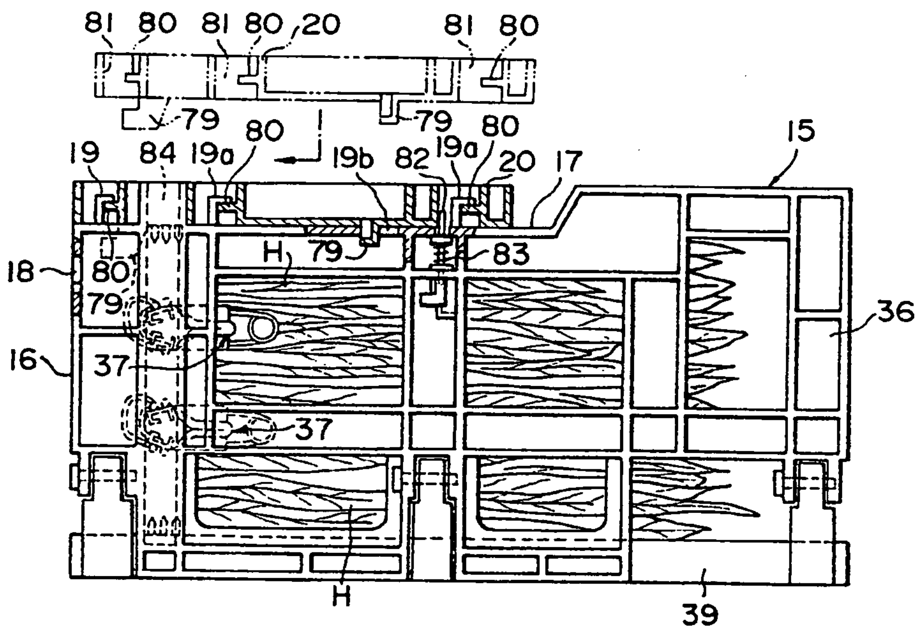

FIG. 12

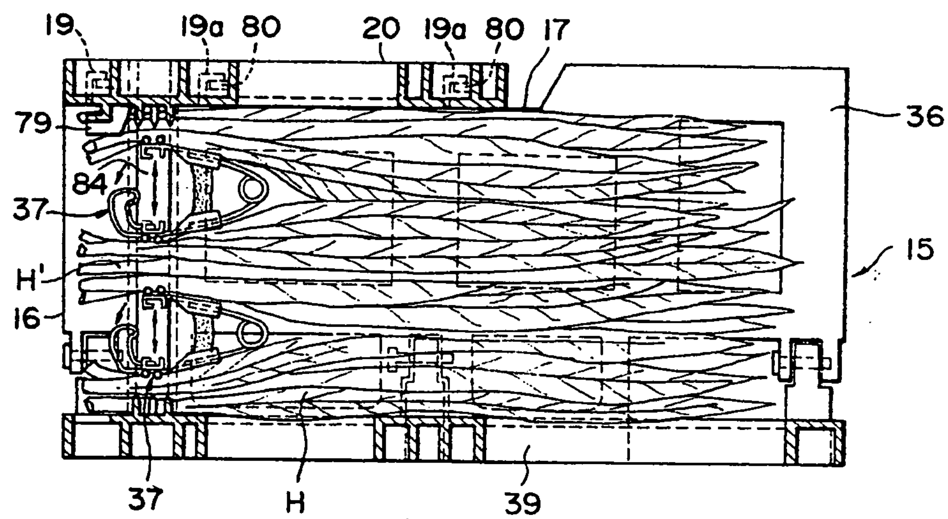

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FIG. 13

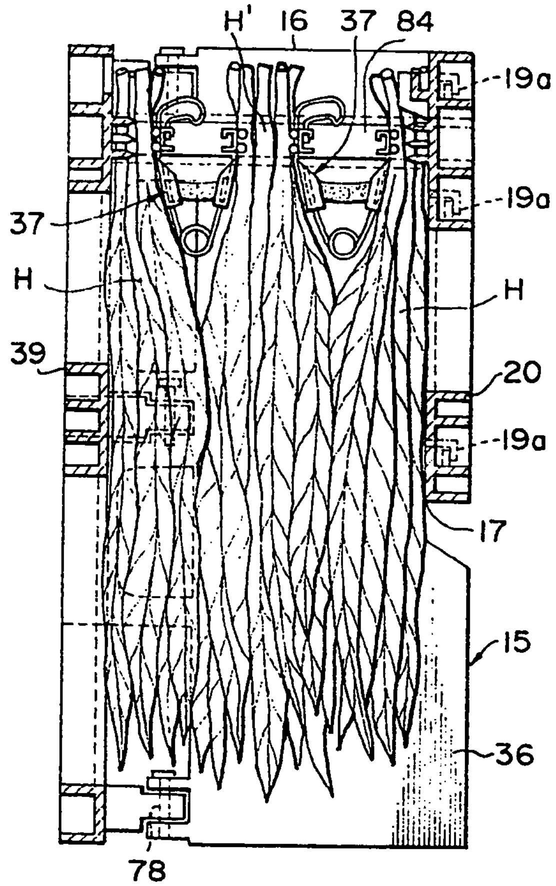

FIG. 14

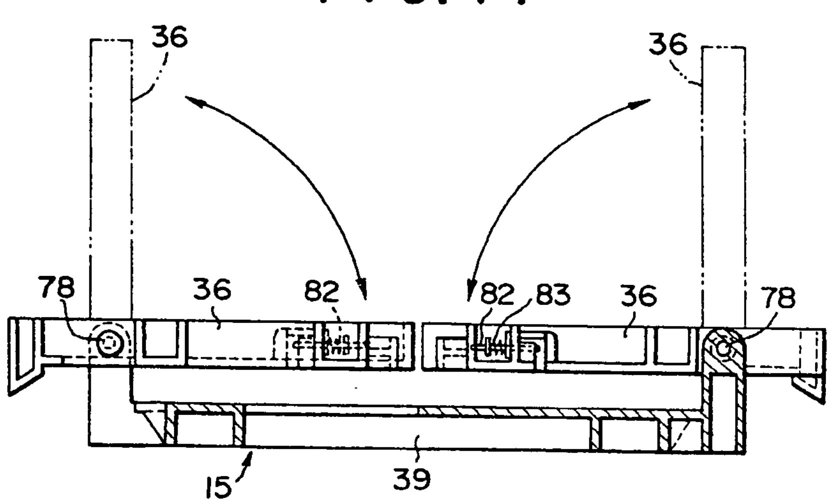

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FIG. 15

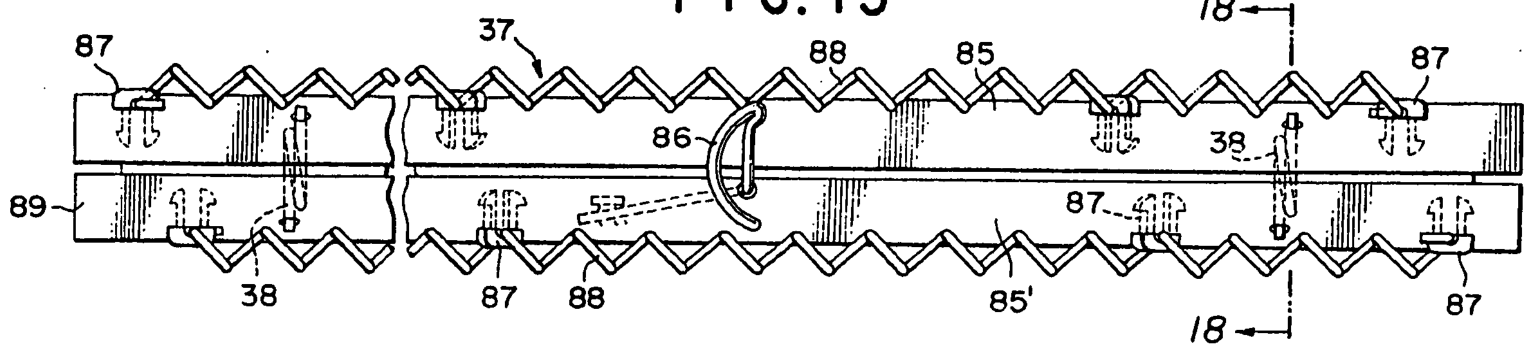

FIG. 16

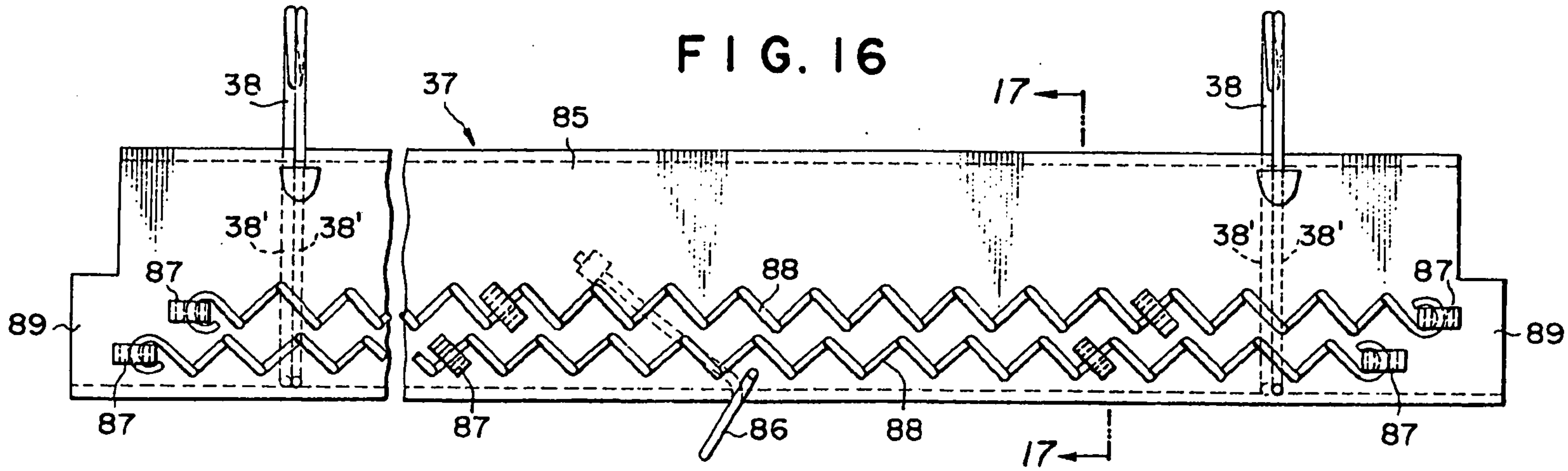

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FIG. 17

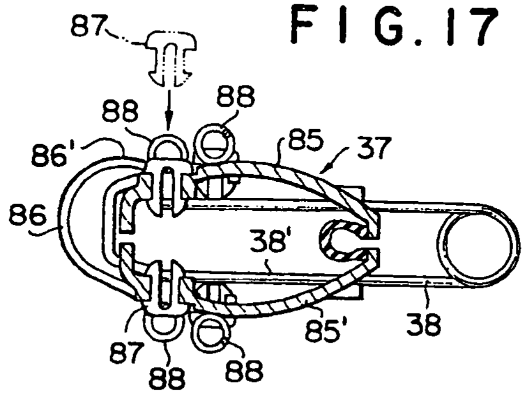

FIG. 18

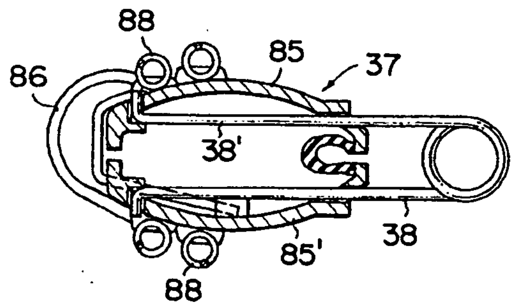

FIG. 19

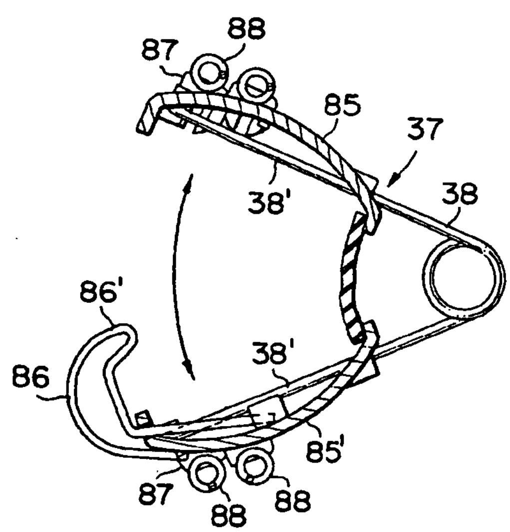

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FIG. 20

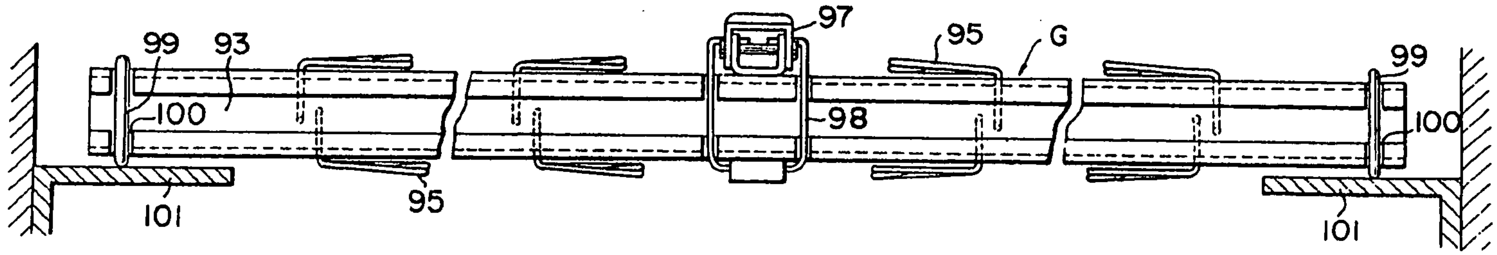

FIG. 21

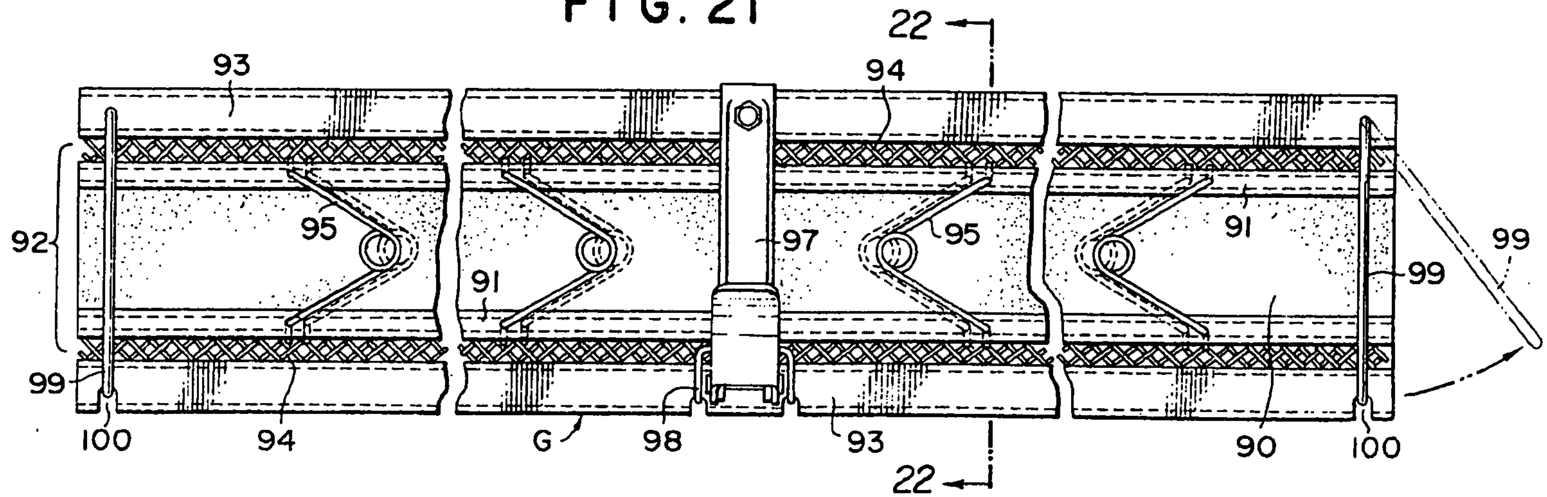

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FIG. 22

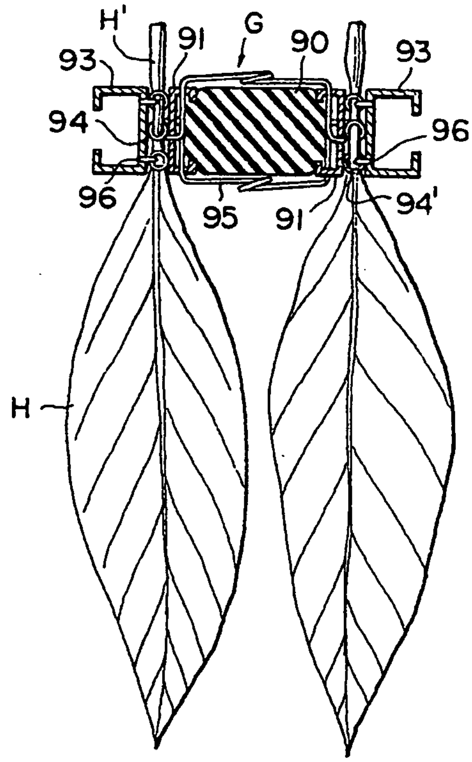

FIG. 23

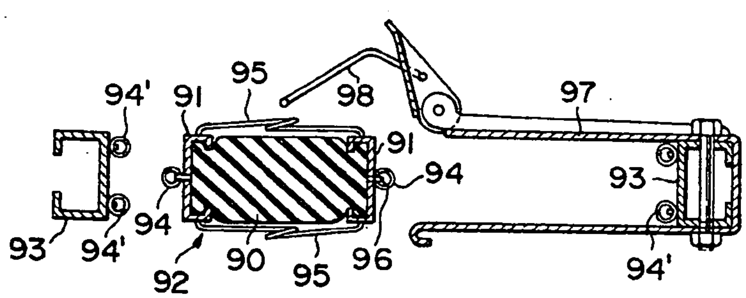

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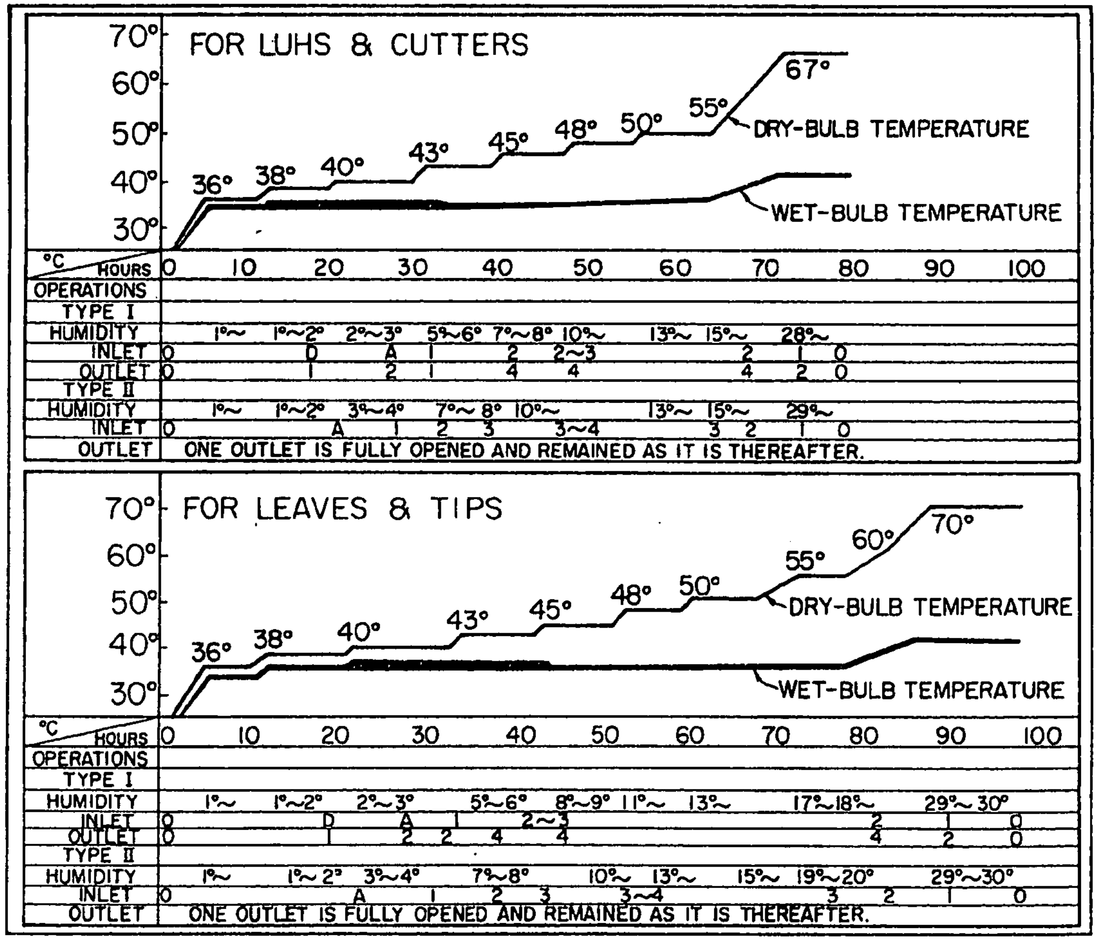
FIG.24



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